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Upgrades to ex-USS *Shadwell* Capabilities: Evaluation of Technology for the Implementation of a Shipwide Video System

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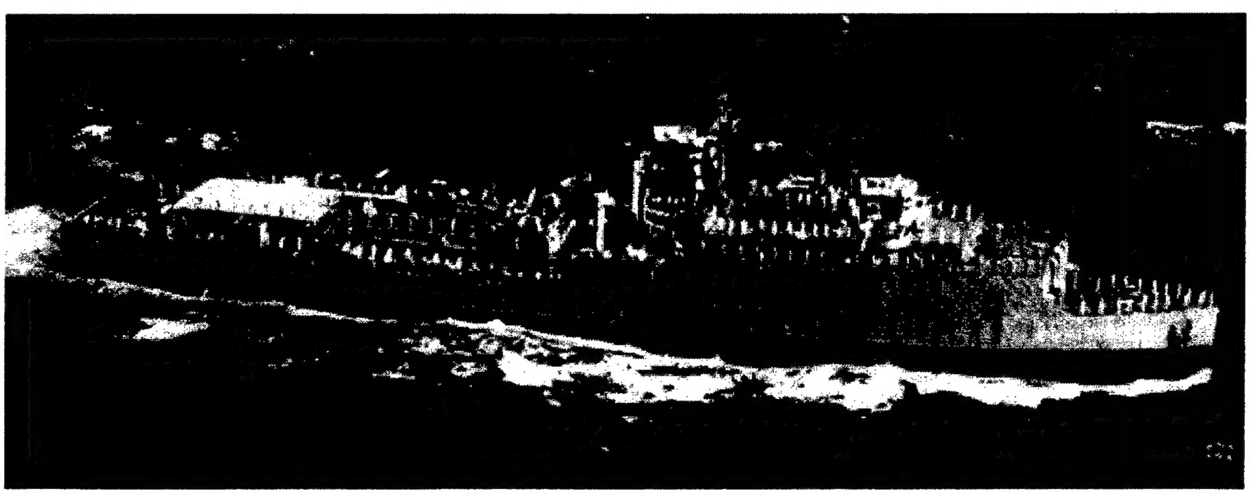
April 19, 2004



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14. ABSTRACT

This report details current video technology to support the implementation of a shipwide video system capable of viewing, recording, and playback of video images from up to 200 cameras in ship compartments and passageways with video functions controlled from a central control room.

15. SUBJECT TERMS

Video; Network video servers; Large scale video system damage control; Network video recorder; Shipboard communications; Reduced manning; Digital video recorder

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Upgrades to ex-USS *Shadwell* Capabilities:
Evaluation of Technology for the Implementation of a Shipwide Video System

1.0 INTRODUCTION

There are many programs supported by the highly instrumented ex-USS *Shadwell*, the Navy's full scale fire research and test ship [1], where damage control and ship survivability investigations, analyses and evaluations are performed. Ships of the future must be able to perform a multitude of advanced functions not currently available with current technology and to perform them with reduced manning. The eyes, ears and hands of crew members must now be replaced by artificial intelligence, smart sensors, computerized controls and decision making systems. In order to implement these advanced functions, improvements must be made to current technology, problem solving capabilities and, most of all, to shipboard communications. One element of the advanced functions needed for future ships is the ability to monitor and observe conditions within individual ship compartments. Much information on a compartment's environmental condition (smoke, flooding and fire) could be gleaned by simply viewing a video image of the compartment. Programs have already been initiated to obtain even more information from the video images by processing them with advanced algorithms. However, this examination will focus on the ability of current video technology to support the implementation of a ship-wide video system capable of viewing, recording and playback of video images from up to 200 cameras in ship compartments with video system functions (camera selection, record, playback and display of selected cameras) controlled from a central control room. Until recently, video equipment was cumbersome and costly and implementing large and complicated systems involved considerable hardwiring which in a shipboard environment, is especially costly. Recent communication developments have made it possible to implement large camera count systems and greatly reduce hardwiring requirements. This report will analyze cost and equipment requirements for two approaches to implementing a large scale video system on SHADWELL. This system, when installed on SHADWELL, will support the development of advanced damage control functions needed to support the smart ship development approach.

2.0 BACKGROUND

Reduced manning requirements for future Navy ships have driven the development of smart systems to take the place of crew members, make educated decisions in time of need and automate ship functions. Good decisions are based on having good information. Sensors may have the information needed to respond to an emergency, but if that information can't be transferred to the decision maker then it's of little value. Communication systems then become as important as the information. Recently, a gigabit Ethernet communication system was installed on SHADWELL in support of R&D programs for the development and evaluation of damage control and ship survivability systems [2]. This state-of-the-art Ethernet system provides the communication support necessary to implement a ship-wide video system to support smart ship program development and to reduce the hardwired cabling requirement necessary without it. At least two approaches for implementing a ship-wide video system will be reported here. One approach is a hardware intensive solution with

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Digital Video Recorders (DVR) and the other is a hardware/software approach using Network Video Recorders (NVR). Both approaches use the gigabit Ethernet system to transfer and control some 200 video camera sources originating in the ten (10) Ethernet node rooms on SHADWELL, and controlled from a remote control room.

3.0 THE SHADWELL VIDEO SYSTEM SPECIFICATION

A. Video System will be capable of supporting at least 200 IP addressable cameras total (20 from each of 10 node rooms). Full resolution (320 X 240 @ 30 fps X 20) cameras is required. Video compression techniques used to reduce data rates must follow industry standard MPEG & JPEG standard formats commonly used to record video images Video equipment in each node room must be capable of recording at least 20 cameras @ at least 320 X 240 pixel resolution at 30 Frames Per Second (FPS). System must have the capability to record multiple 60 minutes sessions using all 20 cameras @ 320 X 240 pixel resolution. System must have the capability of archiving recorded/selected video in its mass storage units and have the capability to transfer portions or excerpts of recorded or live video to DVD and other storage media for long term archiving or use in reports and presentations.

B. Video recording and support equipment will reside in each equipped node room to:
1. Support remote (from control room) selection and control of 200 node room.
2. Route video from cameras to node room recorder for recording and to control room monitors for viewing.
3. Record camera video at selected frame rates and resolutions (up to 30 FPS is required).
4. Node room equipment must be remotely controlled from the control room.

C. Dual console/work station in the control room will support:
1. Graphical User Interface (GUI) with SHADWELL deck drawings for:
   a. Camera selection and control of all cameras from any node room (Up to 20/node room).
   b. For displaying selected camera video in control room.
   c. For recording selected camera video in node room.
   d. Selection of frame rates and resolutions for recording and displaying camera video.
   e. Controlling record and playback parameters.
   f. Searching recorded video by time and date.
   g. Archiving selected prerecorded video to DVD and possibly other media.
2. Control and display of selected node room cameras:
3. Select and view on control room console's, dual monitors the video from up to 32 cameras from selected node rooms.
4. Control frame rates and resolutions of all cameras from control room.
5. Ability to control PTZ of all cameras (may not to be implemented now).
6. Control and recording in node rooms of at least 20 cameras at up to 30 fpm for up to 60 minutes.
7. Control of DVD and/or other recording device of item (C) for permanent archiving.

D. The node rooms will also;
1. Support up to 20 IP addressable cameras.
2. Record and/or switch up to 20 Cameras at a time on a recorder at frame rates of 30 FPS and resolutions of 320 X 240.
3. Transfer images over gigabit Ethernet backbone for display @ 320 X 240 in control room.
4. Provide long term archive capability in each node room. (NVR, DVR, tape or other device).

E. Video system will be configured and controlled from the control room and will consist of:
1. A dual work station in the control room for a. System configuration over Ethernet (camera selection, recording parameters, monitoring).
   b. System control over Ethernet (start, stop, monitor configuration).
   c. Display of up to 32 cameras selected from any node room.
2. Graphical User Interface (GUI) in control room work station will display.
   a. Display all deck drawings with camera locations marked.
   b. Select cameras to display (in control room and record (in node room)).
   c. Drag and drop camera selection.
   d. Edit and archive video.

F. Record in each node room @ 320 X 240 X 30 FPS:
1. At least 12 cameras X 20 hrs/wk X 12 wks/yr = 2880 hrs/yr.
2. Total storage time shall be 3 to 5 years for node rooms. Please provide options.
3. Locate selected video by time/date hr/min/sec, recall and display in control room and/or record to DVD or other media in control or node room.

4.0 TYPES OF VIDEO SYSTEMS CURRENTLY USED

A. Closed Circuit Television (CCTV)

This video system type is the grandfather of all distributed video systems. It is the simplest of all systems and has few components. Video from the cameras to the control and recording equipment can be very lengthy requiring complex video amplifiers and transceivers to accommodate video signal requirements for signals transferred over long runs of video cable. This system type is composed of:

1. Analog video cameras (Color or Black and White).
2. Coaxial cabling between system components.
3. Color or Black & White dedicated cameras and monitors.
4. Off-the-shelf VCR to record the video from a single monitor.
5. Use of video amplifiers due to some long video cables.
6. Use of video transceivers due to some long video cables.
7. Expensive AC or DC camera power feeds required.

B. Multiplexed Closed Circuit Television (CCTV)

This system is the most common in use today. It consists of analog color or black and white cameras tied to video multiplexers (depending on the system configuration). This system receives video feeds from a group of cameras, usually up to 16, to a multiplexer or "MUX". These feeds are individual RG-6 video cables fed directly from each camera to the MUX. The feeds of video can be very lengthy and sometimes require complex video amplifiers and transceivers to accommodate the long runs of video cable. In one configuration, the MUX cycles thru each of the up to 16 video feeds and outputs a single video feed for a video monitor or time lapse VCR in a variety of ways.
This single output is commonly referred to as the "monitor loop out" and usually cycles between selected feeds, displaying each one for a preset finite period out time. This continues until all selected feeds are cycled, and the process begins again. This is the least effective coverage due to the fact that only one camera feed is monitored at a time.

In another configuration, (split, quad, hex and other grouped images) video is displayed on one screen from 2, 4 or 16 cameras simultaneously. This gives the operator a view of all selected cameras simultaneously. Other monitor view configurations are possible, but may vary with equipment manufacturer's specifications. This system offers the least resolution available when multiple feeds are displayed simultaneously. The resolution is inversely proportional to the number of feeds shown on the monitor. (Two feeds displayed = ½ display quality each, four feeds displayed = ¼ display quality, hex + 1/16 display quality, etc.) Attempts to extract identifying information in hex are effectively futile.

The performance of these systems is typically very low. One to two frames per second of video per camera feed is the maximum capacity when fully implemented. A few systems can attain higher frame rates, but are much more expensive.

C. Digital Video Recorder (DVR) Hybrid Digital/Analog System

The most common systems on the market today are of this type. A hybrid digital/analog system with a dedicated personal computer (PC) or similar equipment that receives video from attached video capture cards. The cards have a video port or ports on them to plug the analog video cables into from each camera in the system. The components comprising this system are the same as for and (B) above except the video is displayed on a computer monitor or monitors and is recorded on the computer's hard disk drives. Selection of software to control the video system is extremely important because it is the man machine interface used to select and control cameras, control the video recorder for viewing and recording images and managing long and short term video archives. The software is also important in selecting, controlling and viewing archived video by controlling the functions of the DVR recorder system. The system functions are similar to (B) above. These systems have a typical performance of 1 to 2 frames per second of each video feeds.

Higher frame rates can be obtained at a much higher cost. This system requires RG-6 video cables and camera power to be provided to each camera, at great expense when long cable runs are
necessary. Video quality suffers over long distances. Some of these systems use Web access to the system to allow remote viewing of the video and archives. This system uses the DVR as a source of the video feeds.

Implementing A Digital Video Recorder (DVR) Hybrid System On ex-USS *Shadwell*

Planning a 200+ camera video system for SHADWELL using the DVR hybrid digital/analog approach and meeting the video system specification in (3) above, required some tradeoffs. Most of the equipment used by this system to select, control, record and display video is designed with a 16 cameras limit. To implement a 20 camera/node room system, duplication of equipment at substantial cost is required. For this reason a 16 camera/node room system will be analyzed here. The total system consists of two equipment packages; one to equip the control room and one to equip each node room. This system also employees licensed software necessary for system operation and control, which is sold on a per camera basis and designed to communicate control signals and video over the gigabit Ethernet system on SHADWELL.

Typical Digital Video Recorder Installation On ex-USS *Shadwell*

An equipment diagram of the DVR based hybrid system for the control room/node room #1 is shown in Figure 1. Since the control room also contains a node room, sixteen cameras are included in this setup. The cameras are input via BNC cable from ship compartment locations around the node room to a CM9760 48 X 48 input matrix switch, in the control room, used to switch the node #1 camera videos, incoming network video (from other node rooms), select cameras for recording and display and interface with the VMX 300-Q system control unit. Video from node room cameras received in the control room must be decoded from a network packet format (TCP/IP) to an analog format before being handled by the analog switch, recorder and display. The analog decoding is done by a Pelco Net 350 R

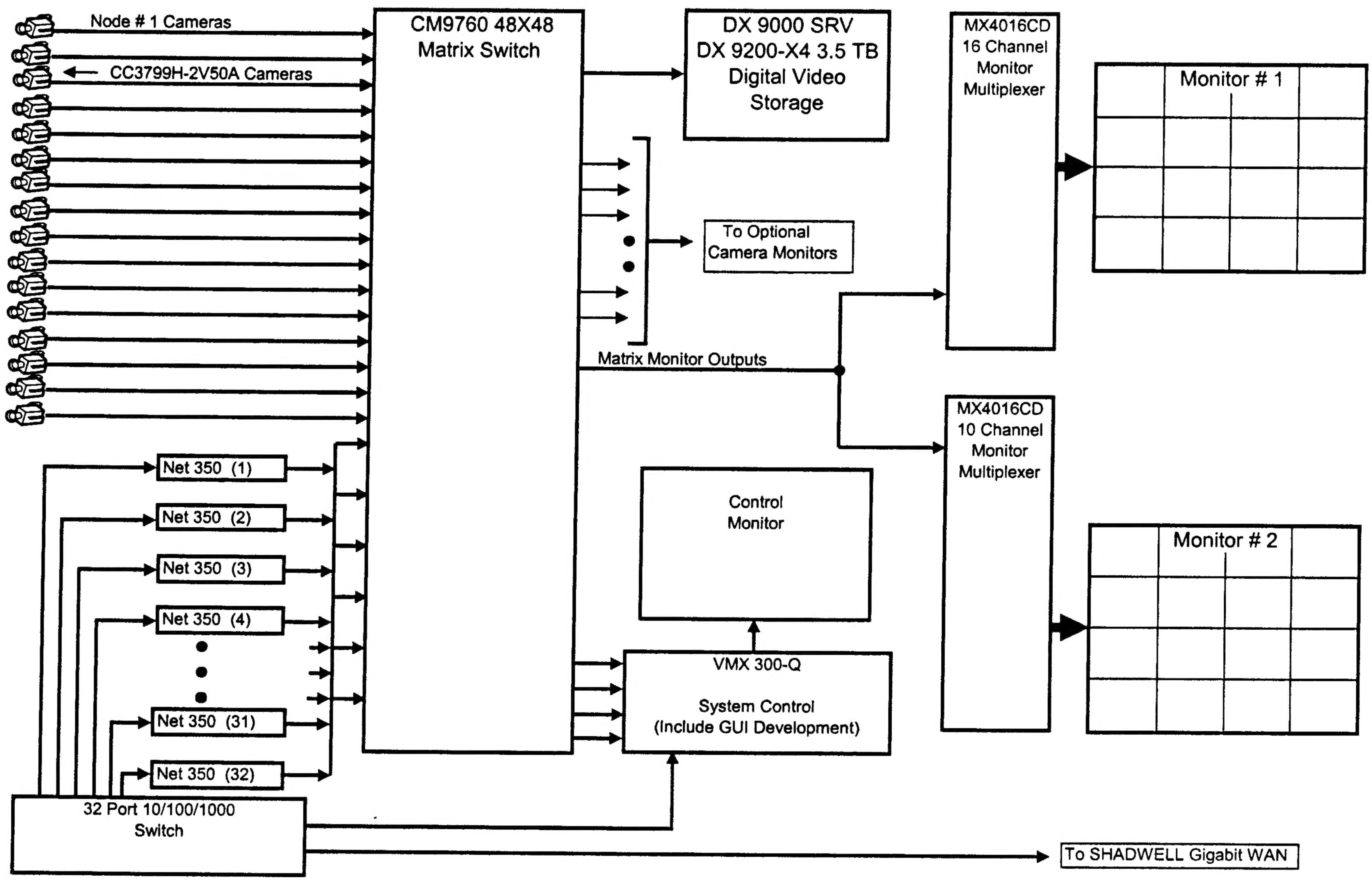

Figure 1. Digital Video Recorder (DVR) Control Room & Node #1 Setup

network decoder/ receiver. A DX 9000 SRV w/3500 GB of digital storage is used as the digital video recorder (DVR) and uses MPEG video compression to conserve digital storage space and to lower data transmission rates. Two MX 4016CD monitor multiplexers distribute 32 video images between two monitors. Table 1, lists the equipment and equipment costs for this implementation. In addition, a control room console and equipment racks will be required to house the system components and to provide work space to control the video system. The node room arrangement for the DVR hybrid system is depicted in Figure 2. Sixteen CC3799H-2V50A analog video cameras are input to a CM9760 Master Distribution Unit (MDA) for selection, viewing, recording and distribution to the control room. Sixteen, Pelco Net 300-TX are used to encode the analog camera video into a TCP/IP addressable network format for transmission over the SHADWELL wide area network (WAN) to the control room. A Pelco DX 9016F –C1, 3500 GB digital video recorder digitizes the selected analog camera video for storage in the node room. The node room video storage and retrieval is controlled from the control room using a TCP/IP network connection between the node room equipment, through the gigabit Ethernet WAN, to the control room. This network connection is provided in each node room via a 24 port 10/100 switch connected to the node room edge switch. Table 2, lists the equipment and equipment costs for the node room implementation.

D. Network Video Recorder (NVR) With Digital IP Network Cameras

The network video recorder video system is the state-of-the-art in digital video systems. Implementing a 100% digital design, this system is superior to all previous systems, outlined in (A), (B) and (C) above. Unlike the DVR hybrid system in (C) above, which uses specifically designed equipment to implement video system functions such as the digital video recorder, standard PC's using licensed software can become network video recorders in the NVR system. Analog video cameras are replaced by network video cameras eliminating the need to convert analog video to a network packet format (TCP/IP) for transmission on the LAN. This adds tremendous flexibility to the operation and control of a large (200+ camera) ship wide video system than any of the other approaches and significantly reduces implementation costs. The number of cameras supported in each node room is not limited as in the DVR system. The NVR system can support an unlimited number of cameras in each node room (Limited only by the LAN capacity). This system can be implemented in stages as funding becomes available or R&D programs require. The NVR system uses MPEG compression techniques to reduce bandwidth and digital storage requirements.

Typical Network Video Recorder (NVR) Installations On ex-USS Shadwell

1. NVR System Version #1

The 200 camera NVR video system for SHADWELL is divided into 10 node rooms, each supporting 20 cameras that are located in compartments, passageways and areas assigned to one of the node rooms. Two equipment configurations for implementing an NVR based system are discussed here. In the first approach or version #1, each of the ten node rooms will be equipped with a network video recorder, 20 network cameras and supporting equipment that is controlled from the control room. With this system, the node recorder can record the assigned node

Breakdown of Hardware To Implement Pelco Control Room & Node 1

Item Name	Model #	Use	Number Required	Unit Cost	Total Cost
Camera	CC3799H-2V50A		16	$411.00	$6,576.00
Network Receiver	NET 350 R	Camera to Network	32	$601.27	$19,240.64
Pelco Rack Kit	300 Rack Kit	Mount Net 350's	7	$52.87	$370.09
Video Matrix Switch	CM 9760 48X48	Video Switching	1	$13,902.00	$13,902.00
Keyboard	CM9760-KBD	Control of Switcher	2	$1,349.00	$2,698.00
Monitor Multiplexer	MX4016CD	Select Display	2	$1,633.00	$3,266.00
21" Monitor	PMC21A	Display Video	3	$450.00	$1,350.00
Video Management	VMX300-E-CSVR-4	Manage Video	1	$7,558.39	$7,558.39
(Above Item Includes GUI Development)					
VMX3000 License	VMX300-LIC200	Software Use	1	$8,748.53	$8,748.53
Digital Storage	DX9016F-C1	2880 Hrs/1Yr	1	$50,600.00	$50,600.00
Network Switch	HP2524	Network Connection	2	$1,143.00	$2,286.00

Table 1. DVR Based Video System Hardware Costs - Control Room/Node #1

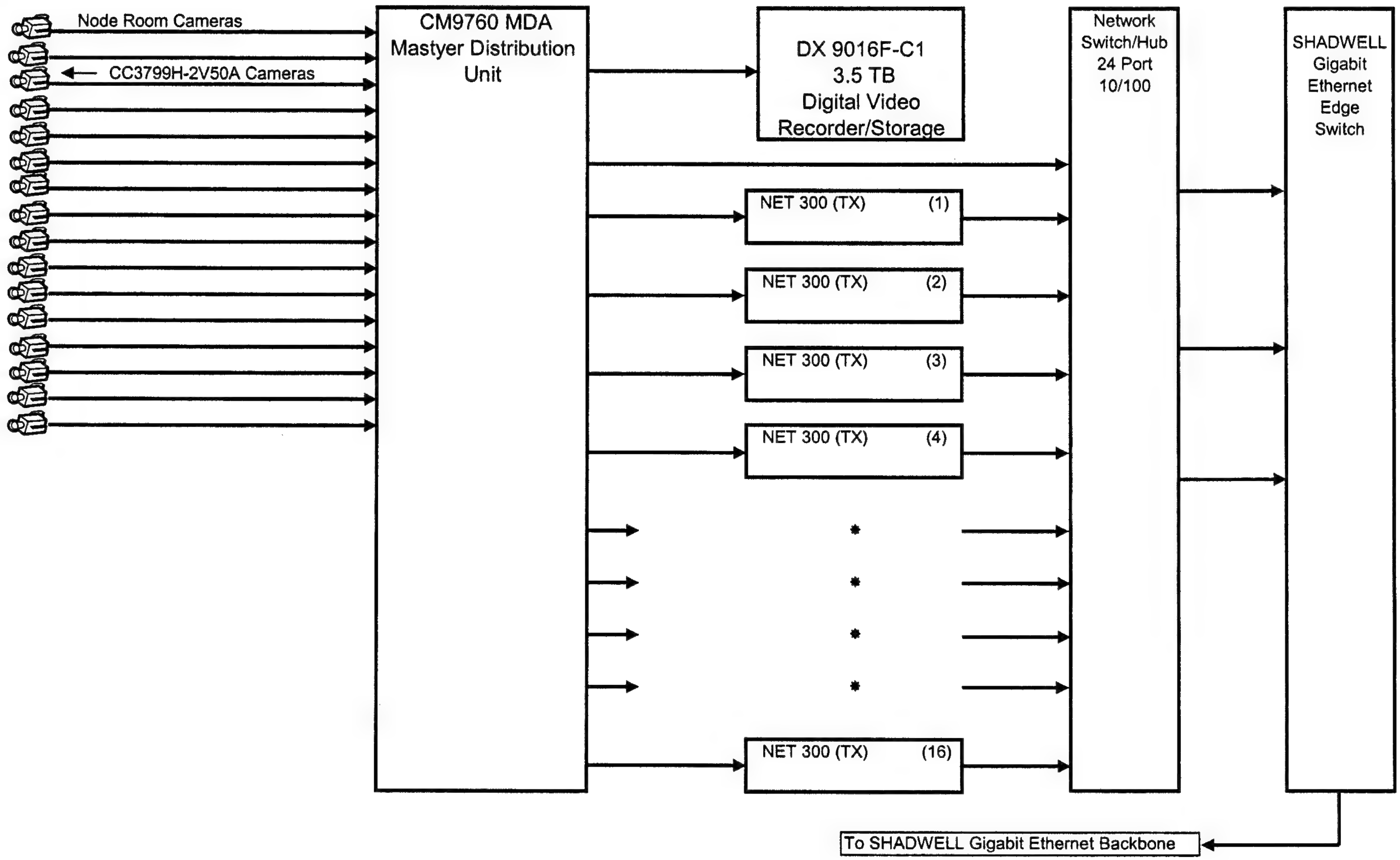

Figure 2. Digital Video Recorder (DVR) Node Rooms #2 Thru #10

Breakdown of Hardware To Implement DVR System In Node Rooms

Item Name	Model #	Use	Number Required	Unit Cost	Total Cost
Camera	CC3799H-2V50A		16	$411.00	$6,576.00
Network Transmitter	NET 300 T	Camera to Network	16	$601.27	$9,620.32
Pelco Rack Kit	300 Rack Kit	Mount Net 300's	4	$52.87	$211.48
Master Distrib Unit	CM 9760 MDA	Video Distribution	1	$1,323.00	$1,323.00
15" LCD Monitor	PMCL15A	Display Video	2	$1,106.00	$2,212.00
Digital Storage	DX9016F-C1	2880 Hrs/1Yr	1	$50,600.00	$50,600.00
Network Switch	HP 2524	Network Connection	1	$1,143.00	$1,143.00

Table 2. Digital Video Recorder (DVR Equipment Costs For Node Rooms

cameras and selected cameras from any other node. The node video can also be displayed in the control room. The control room NVR can recall, search, display and record to DVD the prerecorded video from any camera in any node room. It can also cause any camera to be recorded to its assigned node room NVR. Each node room is capable of archiving 2880 hours of video at 30 FPS as currently designed for version #1. A block diagram of Version #1 of the NVR system for the control room/node room #1 is depicted in Figure 3. Since the control room setup also includes node room #1, twenty (20) cameras are included in this arrangement, as per the system specification. As you can see from the diagram, the amount of hardware to implement this approach is considerably less than the DVR based system. Network video cameras are employed in this system approach instead of analog cameras and are input to a 24 port 10/100 MB/s network switch. This switch is connected directly to the gigabit Ethernet system edge switch located in node room #1, to the SHADWELL LAN and to the PC based NVR. Software which controls this system is also resident in the PC. A system control monitor is used to access system control functions of the NVR and two larger monitors are used to display up to 32 node room cameras (16 on each monitor) which are selected via a graphical user interface (GUI) resident in the PC. The control room PC's software enables the system to control camera selection, recording and playback in all the node rooms. Table 3, lists the equipment and equipment costs to implement the control room node room #1 on SHADWELL. Figures 4 and 5 are drawings depicting a control room console/workstation to operate the shipwide video system. The node room equipment configuration for the NVR system is shown in Figure 6. As you can see from the diagram, this setup is similar to the control room configuration. Twenty (20) network cameras are input to a 24 port 10/100 MB/s network switch. As in the control room configuration the network switch is connected to the gigabit Ethernet edge switch, to a PC based NVR and to the SHADWELL LAN. A monitor is used for node room operation and system troubleshooting purposes. The node room NVR systems are designed to be operated and controlled from the control room. Table 4, lists the equipment and equipment costs to implement each node room (node room #2 thru node room #10) in the system. Since node rooms are operated independently, they can be equipped incrementally as funds and program requirements dictate. Figure 7, illustrates the node room equipment configuration for the shipwide video system.

2. NVR System Version #2

The second NVR equipment configuration approach or version #2, implements an NVR in the control room only, as shown in Figures 8 and 9. The NVR in version #2 has a reduced archival capability of 1028 hours due to the desire to archive the recorded video to DVD and to reduce long term storage capabilities in the original specification to reduce initial implementation costs. Version #2 eliminates the 20 network cameras in node room #1 that are supported in Version #1 for any initial Version #2 implementation. Network cameras in the remaining 9 node rooms are controlled (selection, record, playback and record to DVD) by the NVR in the control room with recorded video stored to NVR storage in the control room. Version #2 will reduce implementation costs significantly due to the elimination of NVR's in the node rooms and the cameras supported by the control room/node room #1, see Table 5 and 6. Upgrades to storage and/or operational capabilities for Version #2 can be made incrementally, as necessary. The operation of the Version #2 NVR equipment will be exactly like the operation of the Version #1 equipment and any differences in system configurations will be transparent to the user/operator.

Breakdown of Hardware To Implement NVR System For Control Room/Node 1

Item Name	Model #	Use	Number Required	Unit Cost	Extended Cost
Network Video Camera	Axis 2120	Video Camer: *** #1, #2	20	$875.00	$17,500.00
Monitor	SAM-213T-BLACK	Video Monitor	2	$1,295.00	$2,590.00
Monitor	SAM-191N-Black	System Control Monitor	1	$678.00	$678.00
Network Switch	HP 2524 w/Two GB Transceivers	LAN Connection	1	$1,143.00	$1,143.00
Control Software	Softsite32	System & NVR Control	20	$499.80	$9,996.00
72" Workstation	Black Box RF500	Video Work Station	1	$3,360.00	$3,360.00
***** See Figures 4 & 5 For Custom Video Console Proposed For Control Room/Node #1 *****					
GUI Development	JDS Digital Systems	Graphical User Interface	1	Negotiable	Negotiable
Network Video Recorder	IronPC 4U ProX SATA NVR	NVR	1	$11,336.00	$11,336.00

Network Video Recorder Consists Of:

ATX - E7505 - Dual Xeon - Gigabit Enabled Motherboard
Two 3.06 MHz Intel Xeon 533 FSB Processors
Two 8 - Port SATA RAID Controllers
Fifteen - 250 GB 7200 RPM SATA Hard Disk Drives
2 GB DDR ECC RAM Memory
Matrox G550 Video Adapter
4U Rackmount Case W/16 Hot-Swap SATA Drive Bays
650 Watt 2+1 Power Supply
Windows XP Professional
Slim DVD/CD and Floppy Drive

NOTE: *System developer has indicated that the cost of the GUI development is negotiable. Estimated at $7K - $10K*

#1 Does not include special camera lenses or environmentally necessary camera housings

#2 Does not include CAT 5 Network cabling. Camera power can be supplied W/CAT 5 network cabling without additional power supply cabling.

Table 3. Network Video Recorder (NVR) Hardware Costs - Control Room/Node #1 (Ver #1)

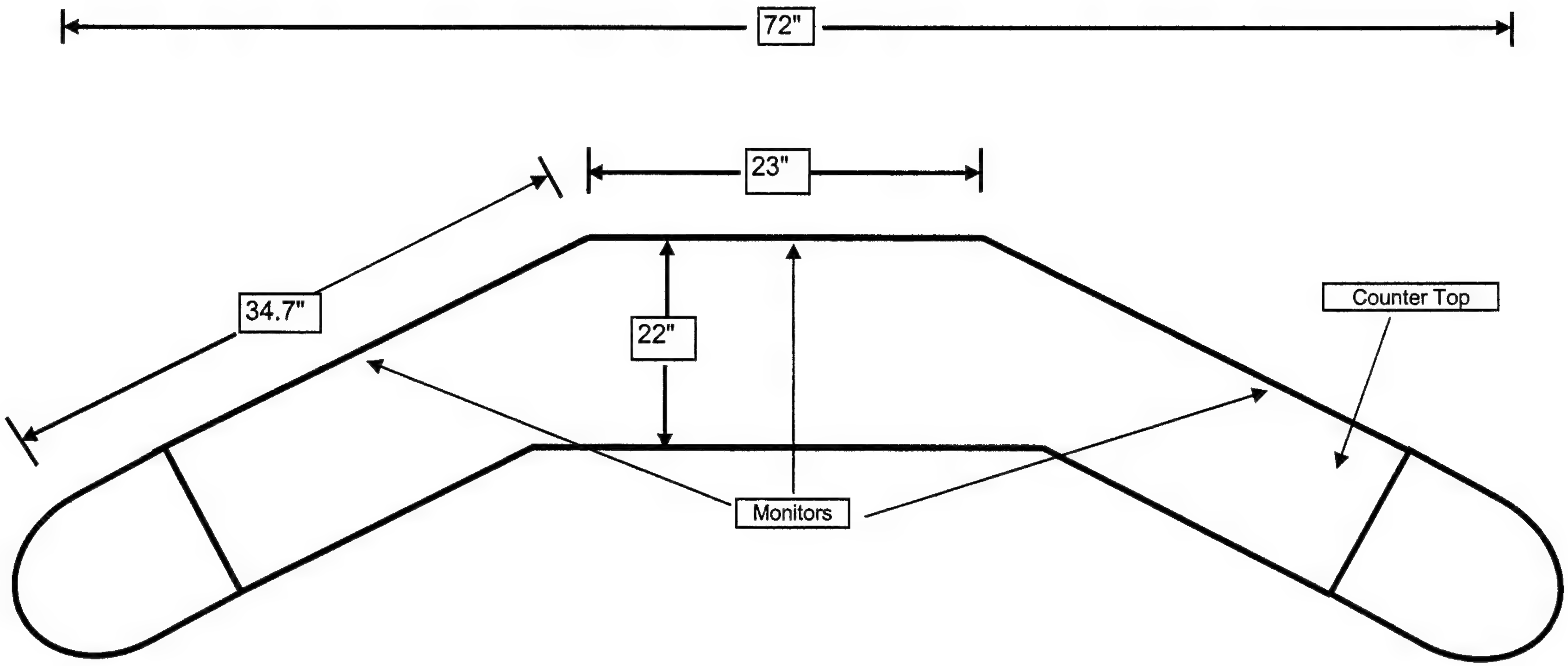

Figure 4. Proposed NVR System Control Room/Node #1 Console (Top View)

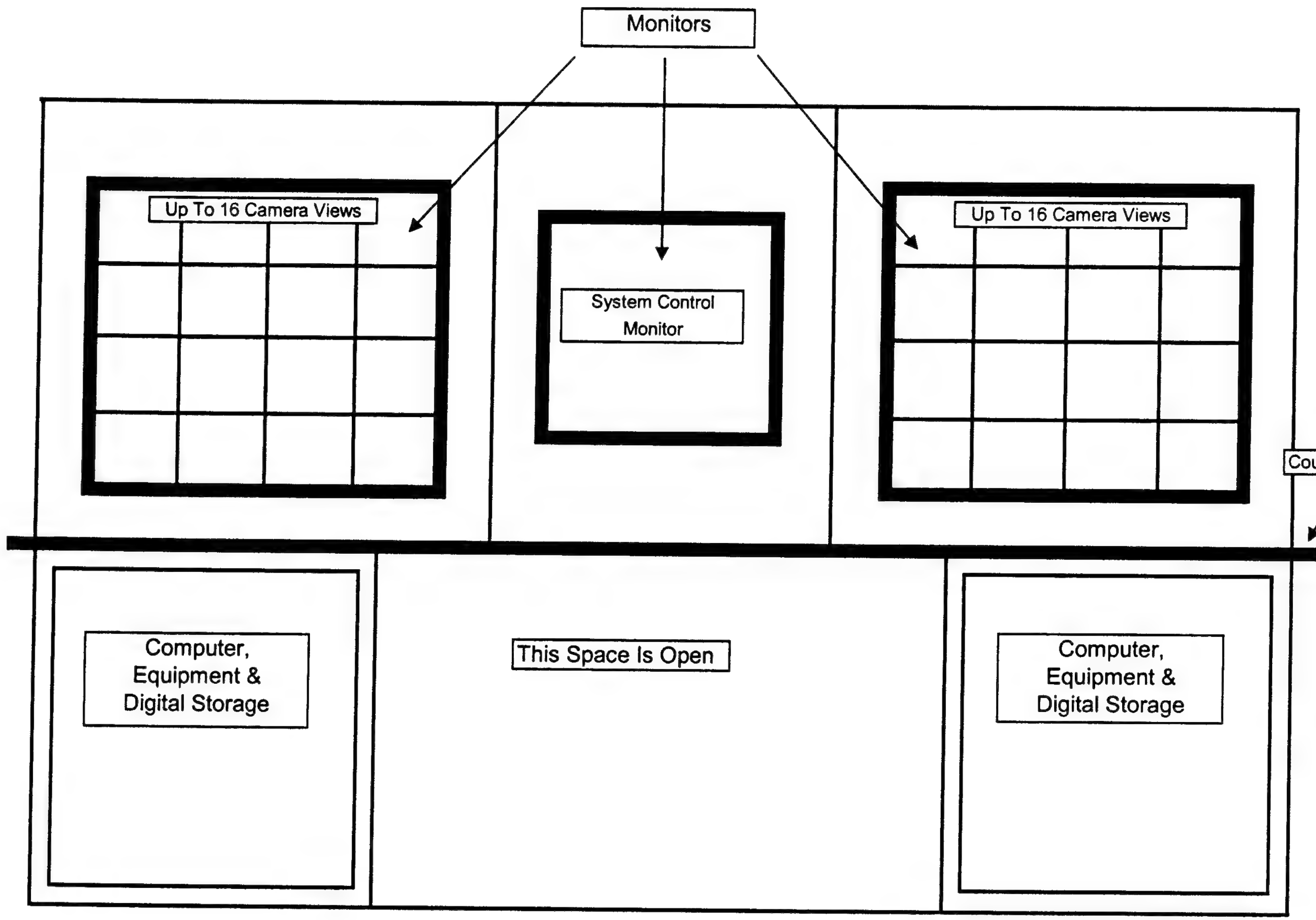

Figure 5. Proposed NVR Control Room/Node #1 Video Console (Front View)

ex-USS SHADWELL Network Video Recorder (NVR) Based System

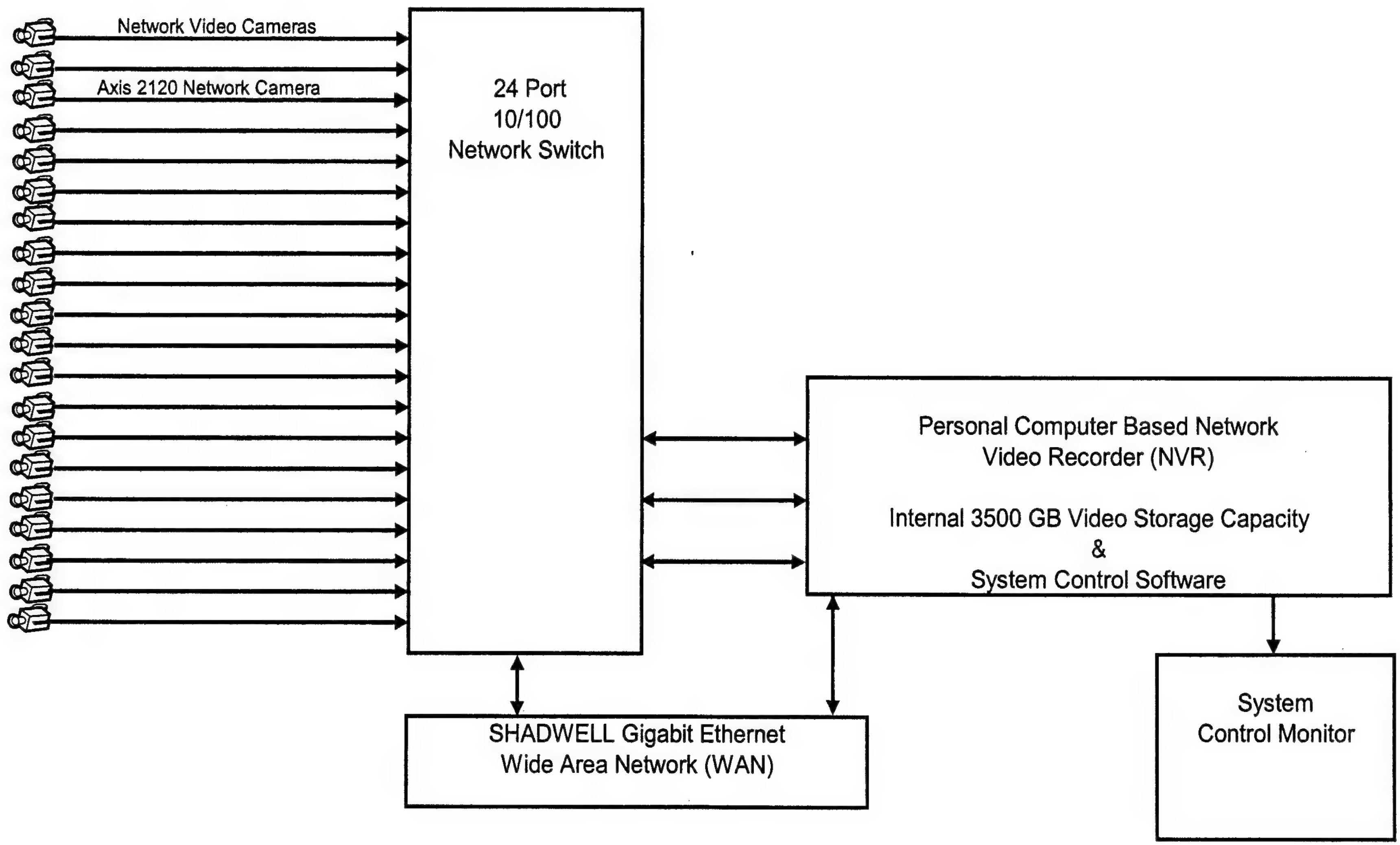

Figure 6. Network Video Recorder (NVR) System For Node Rooms #2 thru #10 (Ver #1)

Breakdown of Hardware To Equip Each Node Room (2 Thru 10)

Item Name	Model #	Use	Number Required	Unit Cost	Extended Cost
Network Video Camera	Axis 2120	Video Camera	20	$875.00	$17,500.00
Network Video Recorder	IronPC 4U ProX SATA NVR	NVR	1	$11,336.00	$11,336.00
Monitor	SAM-191N-Black	System Monitor	1	$678.00	$678.00
Network Switch	HP 2524 w/Two GB Transceivers	LAN Connection	1	$1,143.00	$1,143.00
Control Software	Softsite32	System & NVR Control	20	$499.80	$9,996.00
Equipment Rack	Black Box RM440A-R2	Equipment Support	1	$1,000.00	$1,000.00

Table 4. NVR System Hardware Costs - Node Room #2 Thru #10 (Ver #1)

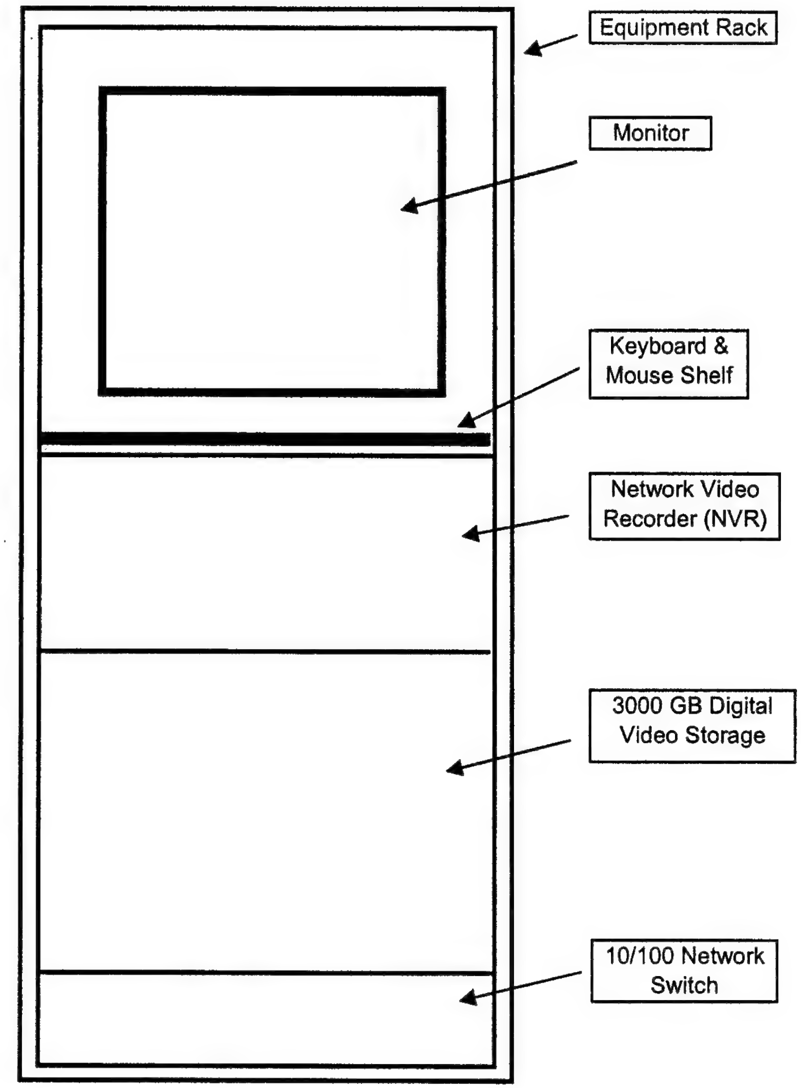

Figure 7, Network Video Recorder (NVR) Node Room (#2 thru #10) Equipment Configuration

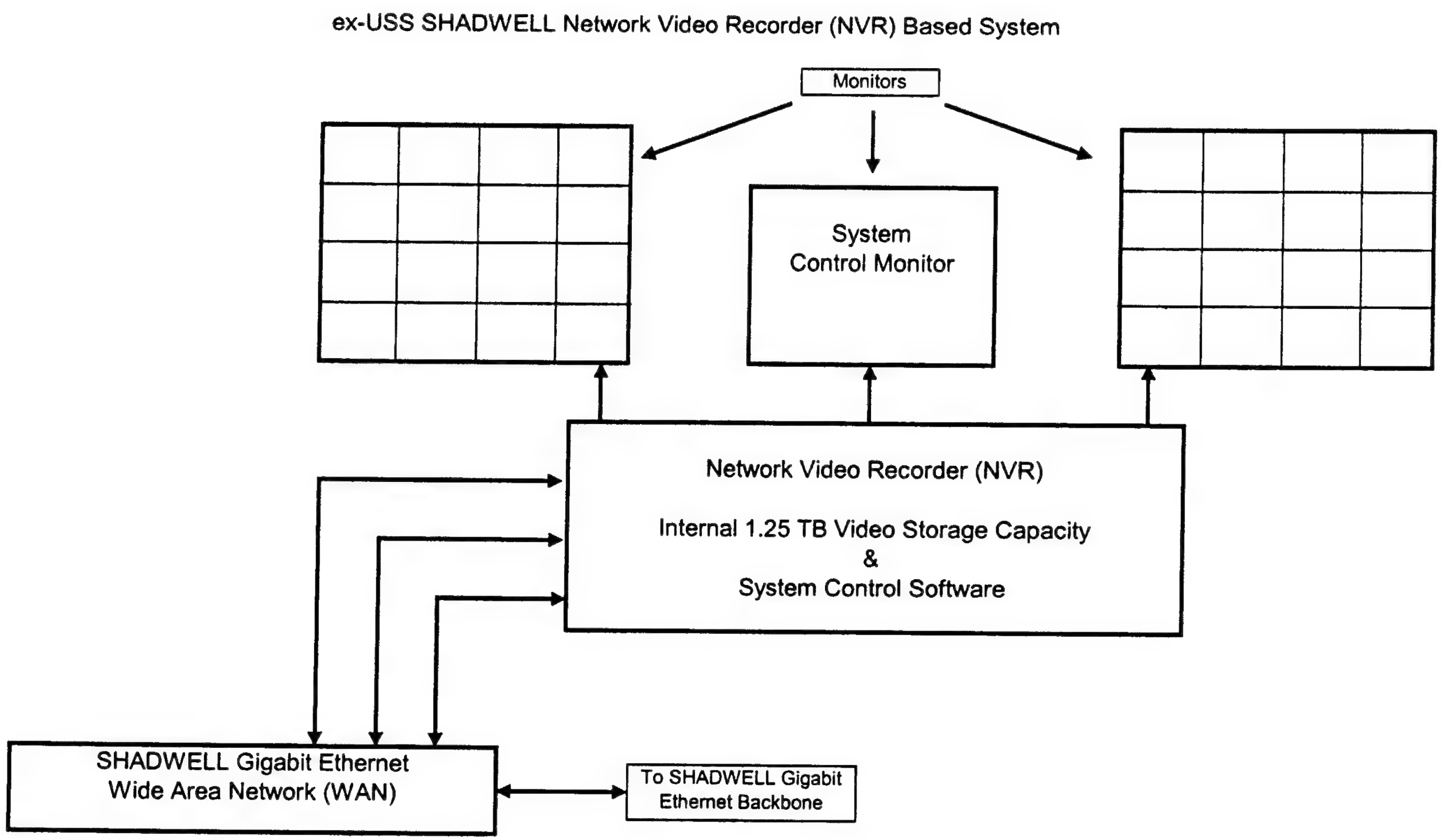

Figure 8. Network Video Recorder (NVR) Video System For Control Room & Node #1 (Version 2)

ex-USS SHADWELL Network Video Recorder (NVR) Based System

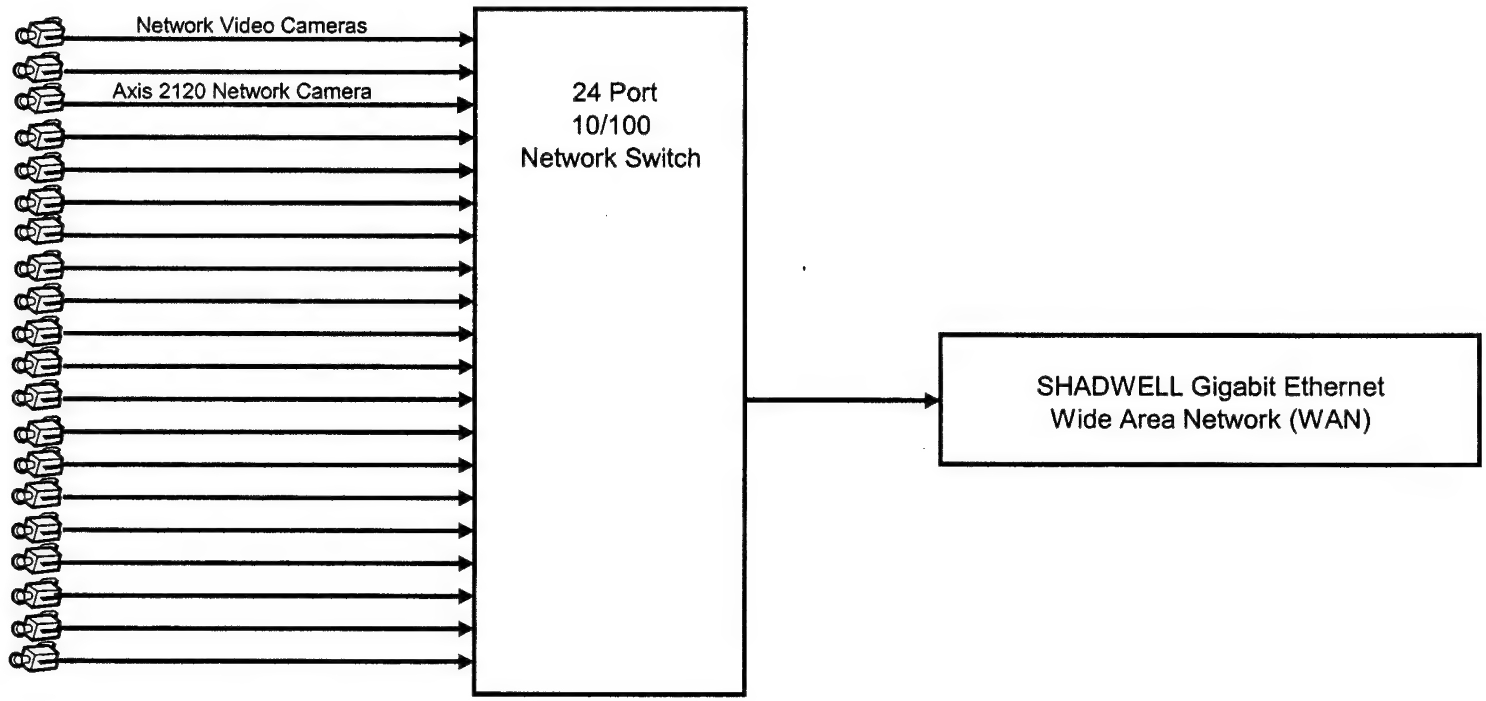

Figure 9. Network Video Recorder (NVR) System For Node Rooms #2 thru #10 (Version 2)

Breakdown of Hardware To Implement NVR System For Control Room & Node 1

Item Name	Model #	Use	Required	Number Unit Cost	Extended Cost
Monitor	SAM-213T-BLACK	Video Monitor	2	$1,295.00	$2,590.00
Monitor	SAM-191N-Black	System Control Monitor	1	$678.00	$678.00
Control Software	Softsite32	System & NVR Control	Per camera	$499.80	499.80 X # Cameras
72" Workstation	Black Box RF500	Video Work Station	1	$3,360.00	$3,360.00
GUI Development	JDS Digital Systems	Graphical User Interface	1	Negotiable	Negotiable
Network Video Recorder	IronPC 3U ProX SATA NVR	NVR	1	$8,760.00	$8,760.00

Network Video Recorder Consists Of:

Mainboard - ATX-E7505-Dual Xeon- Gigabit EN
Two Intel 3.06 Xeon 533 FSB Processors
8 Port SATA RAID Controller
Eight 250 GB 7200 RPM SATA Drives (1.25 TB)
2 GB DDR ECC Memory
Matrox G550 Video Card
3U Rackmount Case W/8X Hot-Swap SATA Drives
760 Watt Triple Redundant Hot-Swap Power Supply
Windows XP Professional
8X DVD+R Write, 4X DVD-R Write, 4X DVD +RW Rewrite, 2X DVD-RW Rewrite and 12X DVD-ROM Drive
Rail Kit

Note: System Developer has indicated that the cost of the GUI development is negotiable, Estimate at $7K - $10K

Table 5. Network Video Recorder (NVR)Hardware Costs - Control Room/Node #1 (Version 2)

Cost Per Node Room

Item Name	Model #	Use	Number Required	Unit Cost	Extended Cost
Network Video Camera	Axis 2120	Video Camera	20	$875.00	$17,500.00
Network Switch	HP 2524 w/Two GB Transceivers	LAN Connection	1	$1,143.00	$1,143.00

Table 6. NVR System Hardware Costs - Node Room #2 Thru #10 (Version 2)

5.0 COMPARISON OF DVR AND NVR BASED SYSTEMS

A. The Digital Video Recorder (DVR) System:

- DVR systems are implemented using equipment which has been specifically designed to function as a digital video recorder. Analog inputs to the digital recorder are routed through a multiplexer (also analog) for recording and viewing and are digitized in the digital recorder. Using separate multiplexer outputs the camera video is routed through network translators and input to a network switch. The network switch provides access for the camera video to be transferred over the gigabit Ethernet system. The DVR system uses MPEG compression algorithms to conserve digital storage capacity.

- Video transferred over the Ethernet system must be recovered from the Ethernet system and transformed back to an analog format in order to be input to the matrix switch, digital recorder, monitor multiplexer and display monitors.

- To satisfy the 20 camera requirement, DVR type systems must use an additional multiplexer because they have a 16 camera limit per multiplexer.

- DVR performance is basically fixed. It cannot be easily augmented, modified or changed and has physical limits. Augmentation requires the duplication of components or the acquisition of premium cost components, costly either method.

- DVR maximum resolutions are limited by analog camera technology and capture card design.

B. The Network Video Recorder (NVR) System:

- PC 's used as an NVR can be used for additional tasks such as advanced analysis of incoming video and data. The NVR recording capacity is effectively unlimited.

- All network cameras used by an NVR are Web servers themselves, allowing for alternate access to the camera video through alternate Ethernet paths. Network video cameras convert video directly to Ethernet data packets for delivery over current networks and can be used instantly. Camera cable runs can be merged to existing TCP/IP connections, keeping cable runs short and performance high. Multiple cameras can be connected together, allowing a single cable run back to the NVR. Cameras can receive power directly from the Ethernet cable connected to it. This can be a big savings in cabling and power supplies. This power over Ethernet is an Emerging standard and available as a benefit when procuring video networking products. Camera manufacturers are known to support this as standard when purchasing their network Camera products. Installation of Ethernet cabling to network cameras can be done by SHADWELL personnel allowing for huge savings on installation costs. Most network camera manufacturers use open APIs to program their digital cameras, this allows the downloading of improved image formats and compression algorithms to upgrade camera capabilities, effectively creating a new camera.

- NVR's are capable of video frame rates well beyond real time (30 FPS) up to 20,000 FPS on common NVR hardware for analysis of video images. This would be useful in research of fast burning fires, explosions, flashovers and image analysis.

- TCP/IP data packets are more secure than analog video cables, because data packets must be captured, reassembled and decoded. SHADWELL Ethernet wide area network (WAN) is not connected to internet so video data packets from cameras can't be intercepted from internet sources. Encrypted data transmissions are also available from some camera manufacturers for use in extreme cases for data security over internet connections.

- Some network cameras have been instrumented with environmental sensors for temperature, humidity and motion detection. They are connected to the camera through an RS-232 connection and their signals are available for integration into a video system GUI presentation. Manufacturers are also interested in developing machine vision concepts into their video systems to facilitate system improvements and upgrades in the video surveillance market.

6.0 RELATED CONCERNS OR LIMITATIONS OF DIGITAL VIDEO:

- Since TCP/IP packets are routed through network hubs, routers and switches which handle other data traffic video frames could be fragmented and delivered in chunks or packets. The timely delivery of these packets can be controlled and modified by the sophisticated switching hardware mentioned above. These systems attempt to manage, load balance and schedule the raw data across the network as efficiently as possible. What this means to the NVR user is that at very high frame rates, video frames may not be delivered at exact fixed intervals. Since the video frames are time stamped to sub millisecond accuracy on arrival to the NVR, computations can show a slight variance in frame to frame delivery time. This variance value is insignificant when playing back the video and usually is below a few milliseconds of variance. For reference, a 30 FPS video feed delivers a frame of video at 33.3333 milliseconds each. Therefore, a 1 to 2 millisecond variance is unperceivable because it will not affect the video being recorded or viewed, however, this could become a problem in very large camera networks due to network packet interlacing saturation. Even in very large camera networks, the recorder video should not be affected due to packet time stamping unless the network is saturated or the PC's aren't fast enough to stream the necessary frame count of all cameras. This would indicate a poor design or inadequate system resources. Careful system design reduces problem areas even in very large camera networks. Systems can be configured with effectively no variance.

- Successful products are eventually mimicked by competing manufacturers. While many similar products are as good or even better than the brand names, some products are designed to be very inexpensive and often compromise quality and performance for the sake of cost. Careful consideration should be given to the importance of quality and reliability in the selection of digital and network video components.

7.0 RECOMMENDATIONS

The DVR hybrid system shown here, for the SHADWELL control room and node rooms is an equipment intensive design. This means that specific hardware was designed to perform needed video system functions, such as digital video recorder, network translation and communication, system control and monitor functions. If modifications or upgrades to the original system specification become necessary, new hardware to perform these new functions will most likely be required. Some equipment can make modifications, upgrades or even completely change their designed functions by modifying or upgrading their software. This is not possible with the DVR hybrid system because of the dedicated hardware designs it employs. Because Network Video Recorders (NVR) use standard personal computers (PC's) to implement NVR functions, software changes can change the way the NVR operates. Dedicated equipment capable of functional modification via software redesign are the wave of the future and will reduce functional obsolescence and costs. The video system envisioned for SHADWELL could be required to assume more capabilities as smart ship development R&D progresses. This could include software analysis of incoming and previously recorded video to support and implement current video analysis efforts in Machine Vision. Network video assets can also be accessed via an internet connection from anywhere in the world provided there is an internet connection to the video system. An internet connection to SHADWELL video assets could provide the ability to remotely access and control those assets for viewing, documentation and transfer of video and data to a remote site such as NRL. Much better use of development assets can be made by using state-of -the-art network equipment, methods and communication systems which would be less prone to early obsolescence and could be easily upgradeable. Implementation costs for NVR systems are considerably lower than other approaches.

8.0 REFERENCES

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9.0 ABBREVIATIONS

DVR	**Digital Video Recorder**
NVR	**Network Video Recorder**
MPEG	**Moving Picture Experts Group**
JPEG	**Joint Photographic Experts Group**
FPS	**Frames Per Second**
PTZ	**Pan, Tilt, Zoom**
GUI	**Graphical User Interface**
IP	**Internet Protocol**
TCP/IP	**Transmission Control Protocol/Internet Protocol**
VCR	**Video Cassette Recorder**
MUX	**Multiplexer**
PC	**Personal Computer**
CCTV	**Closed Circuit Television**
WAN	**Wide Area Network**
LAN	**Local Area Network**